

# Bioaccumulation of Selenium in the Food Chain

## Grades

Any

## Subjects

Science and Health

## Type of Lesson Plan

Activity

## Duration

20 – 30 minutes

## Materials

- Small squares of paper (white and yellow)
  - 20 pieces of white paper per “grasshopper”
  - 10 pieces of yellow paper per “grasshopper”
- Handout
  - *Health Effects of Selenium*
- Paper bags for all grasshoppers

## Objective

TLW...

- Increase their understanding of how the food chain/web functions.
- Understand how toxins can accumulate through the food chain.
- Understand how they can be exposed to toxins by consuming other animals and plants which have been exposed to toxins.
- Be able to obtain information from a government fact sheet.

## Set

Review of the food chain/web. This is an excellent closure activity for the concept of the food chain/web.

## Instructional Input

Break down students into groups of animals. Note: the following grouping assumes a class size of 26. Adjust your groups accordingly. *This lesson can be merged with “Pollution in Fish” for older grades.*

18 grasshoppers

6 lizards

2 hawks

Distribute the white and colored pieces of paper (food) on the floor and give the paper bags to the “grasshoppers.” The pieces of paper represent plants (producer).

Instruct the “grasshoppers” to collect as many pieces of paper as they can. Tell them not to worry about whether they collect white or colored paper. The idea is for them to collect as much food as possible or they will starve. Allow the students 30-45 seconds to collect as much “food” as they can, placing it in their paper bags.

The “lizards” will prey on the lower order consumers, the grasshoppers, thereby collecting their food. Allow only 5-10 seconds for the lizards to prey upon the grasshoppers. If a lizard touches a grasshopper on the shoulder, that grasshopper has been consumed and must surrender their food bag to the lizard. Lizards with fewer than 2 grasshopper bags starve and die.

Finally, allow the hawks to prey upon the lizards in the same manner the lizards preyed upon the grasshoppers. Allow only 5 seconds for the hawks to predate. If a hawk has less than 2 bags, they starve and die.

Now, read the following scenario:

*While feeding on plants, grasshoppers consumed plants which grew in soils with large amounts of the element selenium. Selenium is a naturally occurring element essential for many living creatures. However, too much selenium can cause animals to become unhealthy. The colored pieces of paper in this exercise represent plants high in selenium. Any grasshopper with 10 or more high selenium pieces of food will be unhealthy for lizards to eat. Any lizard that has 25 or more high selenium pieces of food will become sick. Any hawk with 40 or more pieces of selenium will lose their appetite, will stop drinking water, and suffer from paralysis.*

*This example is an extreme case of what scientists call bioaccumulation.*

*Bioaccumulation occurs when plants or animals are exposed to toxins in the environment. Consumers, or predators then eat these animals and plants. As the food is digested, the toxins are absorbed into the system of the animal eating the contaminated food. Since each successive predator must eat a certain number of prey, the toxins start to accumulate more in the predators. Higher order predators are exposed to the greatest amounts of toxins because their prey has accumulated the toxins and the predator must eat a sufficient number of prey. So, if a hawk eats 3 lizards which have 30 units of toxins each, the hawk now has 90 units of toxins. Even if an area has low levels of toxins, the higher order predators can still become sick because those toxins can concentrate in their prey. Higher order predators must consume a large amount of food. If this food is contaminated, those contaminants can build up in dangerous amounts in the predator's body.*

*The same holds true for humans. Imagine that elk, sheep, or deer were feeding on contaminated vegetation. Humans, preying on the elk, sheep, or deer could be exposed to unhealthy levels of selenium.*

## **Closure**

Share the *Health Effects of Selenium* fact sheet with the class if age appropriate. You can read the whole thing or certain sections, or read it as a class.

Ask the class to write a brief essay (5 minutes) about how they think bioaccumulation of toxins can affect human health. Challenge them to come up with an example of their own using a contaminant of their choice and their understanding of food chains/webs.



# IDAHO DEPARTMENT OF HEALTH & WELFARE

## Bureau of Community and Environmental Health

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### HEALTH EFFECTS OF SELENIUM

#### What is selenium?

Selenium is an essential nutrient for humans and animals. Selenium, however, is harmful to humans and animals when eaten in amounts that are much higher than the amounts needed for good nutrition. Selenium is a naturally occurring substance that is widely, but unevenly, found in the rocks and soil of the earth. It is not often found in its pure form. It is usually combined with other substances. In the western states, the soils contain rather high levels of selenium compounds.

Selenium is most commonly produced as a byproduct of copper refining. Selenium compounds can be produced by roasting copper ore "slimes" with soda ash or sulphuric acid. Burning coal and oil also releases selenium into the environment. What happens to selenium when it enters the environment?

- Small selenium particles in the air settle to the ground or are taken out of the air in rain.
- Selenium compounds deposited in agricultural fields from fertilizer use can be carried in irrigation drainage water.
- Plants easily take up selenium compounds from water and concentrate them. Selenium can build up in animals that eat plants or other animals with high levels of selenium. It can also build up in animals that live in water containing high levels of selenium.

#### How might I be exposed to selenium?

- By eating food, drinking water, or taking dietary supplements that contain it.
- By living near a selenium-rich area.
- By living near a hazardous waste site that contains selenium.
- By breathing air that contains selenium.

Many people take daily selenium supplements. The Food and Drug Administration recommends that adults eat 55 micrograms of selenium a day. Selenium activates antioxidant enzymes. Some supplement manufacturers claim selenium can boost the immune system and prevent cancer. These claims have not been scientifically proven.

Humans are exposed daily to selenium in their food. Generally, the levels in food are enough to protect against diseases that may result from too little selenium. Most of the daily intake of selenium comes from eating grains, cereals, seafood, and animal organs.

The human body easily absorbs selenium from foods that are eaten. Selenium in drinking water is easily absorbed in the digestive tract. It is not easily absorbed through the skin. The human body can change selenium into forms the body can use. However, selenium can build up in the human body, leaving mainly in the urine.

Some plants can build up selenium to levels that are harmful to livestock and humans feeding on these plants. In these cases, humans can be exposed to too much selenium if they eat locally grown grains, vegetables, or animals that have built up high levels of selenium.

In fresh water containing high levels of selenium, fish may contain selenium at high levels. Humans also can be exposed to selenium in drinking water. Most of the water sources in the United States contain levels of selenium that are very low compared with levels found in food. Less than 1% of the daily intake of selenium is estimated to come from drinking water. At hazardous waste disposal sites, selenium can be washed from the soil into streams and lakes or flow into groundwater. This raises the amount of selenium in water above normal levels.

Humans normally are not exposed to large amounts of selenium in the air. People who work in metal industries, selenium-recovery processes, painting, and ore processing may be exposed to airborne selenium.

## **How can selenium affect my health?**

Selenium can be harmful at daily dietary levels 5–10 times higher than the daily requirement. The seriousness of the effects of excess selenium depends on how much is eaten and how often. Accidentally swallowing a large amount of selenium (for example, a very large quantity of selenium supplement pills) could be fatal without immediate medical treatment. The exact levels at which these effects occur are not known.

If amounts of selenium only somewhat higher than needed were eaten for a year or more, several health effects could occur. These effects include brittle hair, deformed or discolored nails, loss of hair, tooth decay and discoloration, fatigue, liver and spleen damage, and, in extreme cases, loss of feeling and control in arms and legs.

Currently, we do not know the exact exposure levels at which these effects may occur. Short-term exposure, 14 days or less, to selenium from inhalation of dust results in irritation of the mucous membranes in the nose and throat, producing coughing, nosebleeds, bronchial spasms, and chemical pneumonia. Short-term exposure from inhalation of hydrogen selenide, a highly toxic selenium compound, results primarily in respiratory effects, such as irritation of the mucous membranes, pulmonary edema, severe bronchitis, and bronchial pneumonia.

Indigestion, nausea, headaches, dizziness, and irritation of the eyes also were reported in humans who inhaled selenium compounds. No information is available on the chronic (long-term) effects of selenium in humans from inhalation exposure. Upon contact with skin, selenium compounds have caused rashes, swelling, and pain.

## **What are the effects of selenium on livestock?**

"Blind staggers" is a disease in livestock that results from short-term consumption of plants high in selenium. It is characterized by impaired vision, aimless wandering behavior, reduced consumption of food and water, and paralysis. "Alkali disease" is a disease in livestock resulting from long-term consumption of high levels of selenium. It is characterized by hair loss, deformation and sloughing of the hooves, erosion of the joints of the bones, anemia, and effects on the heart, kidney, and liver.

## **How likely is selenium to cause cancer?**

The U.S. Department of Health and Human Services has determined that selenium sulfide may cause cancer. Selenium sulfide is used in some anti-dandruff shampoos. It is not present in foods and is very different from selenium compounds found in foods and in the environment. Because selenium sulfide is not easily absorbed through the skin, use of shampoos containing this compound is considered safe unless a person has open cuts or sores on the scalp or hands.

Studies of laboratory animals and people show that most selenium compounds probably do not cause cancer. In fact, some studies of human populations showed that not enough selenium in the diet might increase the risk of cancer. But diets high in selenium do not reduce the risk of developing cancer and may increase the risk of selenium poisoning.

## **Has the federal government made recommendations to protect human health?**

The federal government has developed standards and guidelines to regulate exposure to selenium in the environment and to protect individuals from possible adverse health effects. The Environmental Protection Agency maximum contaminant level for selenium in drinking water is 50 parts of selenium per billion parts of water (50 ppb). The Food and Drug Administration maximum allowable level of selenium in bottled water is also 50 ppb.

The Occupational Safety and Health Administration exposure limit for selenium compounds in workplace air is 0.2 milligrams of selenium per cubic meter of air for an 8-hour day over a 40-hour work week.

## **For more information**

The *Bureau of Community and Environmental Health* (BCEH), Idaho Division of Health, works with the *Agency for Toxic Substances and Disease Registry* to protect human health from dangerous substances in the environment. BCEH has an Environmental Health Education and Assessment Program to inform and educate the citizens of Idaho about these substances at hazardous waste sites and the activities being conducted at these sites. This fact sheet has been created to assist you in understanding the potential health effects of exposure to selenium in the environment. For more information, contact:

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